



Calcareous Nannofossil Biostratigraphy of CSDP-002 Well, Central Swamp Depobelt, Niger Delta, Nigeria

¹Ndubuisi Ukpabi, Jeremiah Godwin Udom and Onyekwere Kingsley Okengwu

Geology Department, University of Port Harcourt, P.M.B: 5323, Choba, Rivers State, Nigeria.

¹Corresponding Author Email - edgar2005ng@gmail.com

Received: 22 September 2017, Revised Received: 23 October 2017, Accepted: 29 October 2017

Abstract

The objective of this work is to present the investigated data and result on ditch cutting analysis to understand the calcareous nannofossil biostratigraphy of the studied section. About 103 ditch cuttings were studied covering 6260ft to 12620ft of CSDP-002 well at 60ft intervals. The samples were processed to recover calcareous nannofossils. The processing of ditch cutting samples yielded fifty-three (53) calcareous nannofossils species from fourteen (14) genera. The species included *Discoaster druggii*, *Helicosphaera scissura*, *Sphenolithus heteromorphus*, *Coccolothus pelagicus*, *Helicosphaera ampliaperta* etc. The biozones identified included top NN3 zone indicated with LAD of *Discoaster druggii* and continuous occurrence of *Helicosphaera scissura* below FAD of *Sphenolithus heteromorphus* which marked the base of NN4; NN4 zone indicated with FAD of *Sphenolithus heteromorphus* and/or LAD of *Sphenolithus belemnus* and LAD of *Helicosphaera ampliaperta*; and base of NN5 zone indicated with LAD of *Sphenolithus heteromorphus*. The studied section of CSDP-002 corresponded to 15.0Ma to 17.40Ma in age. It penetrated MFS 15.00Ma; MFS 15.90Ma and MFS 17.40Ma Maximum Flooding Surfaces which were marked based on ACME of *Sphenolithus heteromorphus*, *Helicosphaera ampliaperta*, *Helicosphaera cartari*, *Sphenolithus moriformis* and *Coccolothus pelagicus* with their corresponding abundance and diversity peaks. Two sequence boundary were delineated based on abrupt drop in taxa count to complete disappearance of taxa. This work provides a detailed and predictive chronostratigraphic surfaces for the studied section of CSDP-002 well.

Keywords: High resolution biostratigraphy, Calcareous nannofossils, Chronostratigraphy, Maximum flooding surface, Sequence boundary.

Introduction

The Niger Delta is located in the Gulf of Guinea and it is bounded in the onshore with the Benin Flank on the north; the Cretaceous outcrops of the Abakaliki High

on the northeast and the Calabar Flank on the east-south-east. The offshore part of the Niger Delta is bounded onshore by the Cameroon volcanic line to the east; the Dahomey basin surrounds it from the west

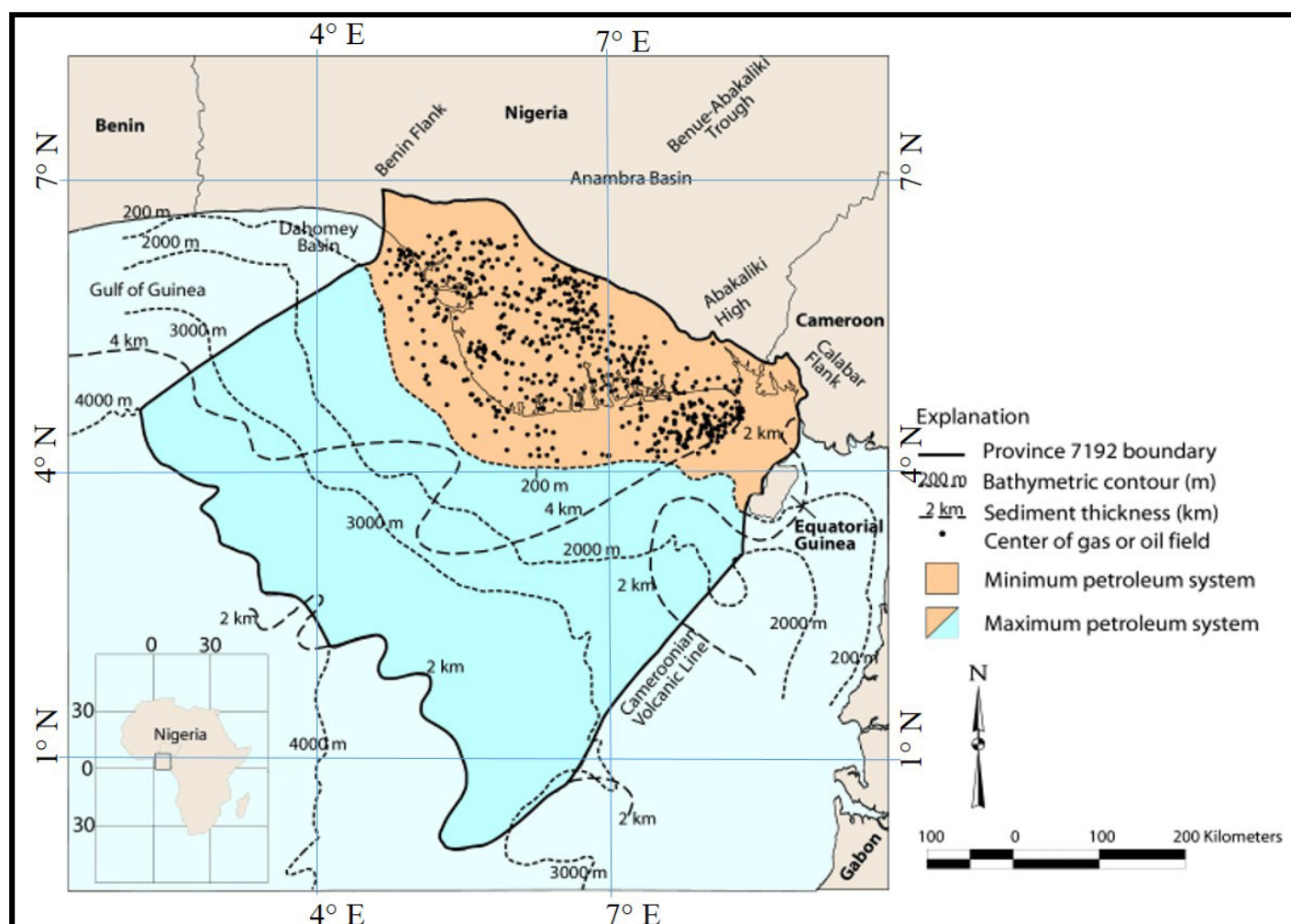


Fig. 1. A map showing the lateral extent of the Tertiary Niger Delta Petroleum System (after Tuttle et al, 1999).

and the Atlantic Ocean to the south (Tuttle et al, 1999), (Fig. 1). Sedimentation in the Niger Delta began with a regression in the early Eocene which led to the deposition of the three major lithostratigraphic units (Doust and Omatsola, 1990). The southwestward progradation of the Niger Delta induced formation of depobelts which are active portions for accumulation of sediments (Fig. 2). These depobelts of which the central swamp is one, was formed in response to rate of sediment supply, accommodation space and the structural instability of the underlying un-dewatered Akata Formation by the overlaying denser sands of the delta front Agbada Formation. Structural instability in the Niger Delta accounted for the extensive lateral facies variation due to extensive

faulting, this in turn affected the geological principles such as principle of faunal succession, superposition, original horizontality and lateral continuity in the study area. The accurate determination of sequences in the study area can only be made possible through proper identification of fossil taxa and their associations (biofacies) for accurate biostratigraphic correlation. This study would provide proper chronological and stratigraphic sequences in the study area through biostratigraphic data gathering with emphasis on calcareous nannofossil. CSDP-002 well is located in Longitude 6°37'E and Latitude 5°10'N within the central swamp depobelt (Fig. 3). 103 ditch cuttings were sampled from CSDP-002 well at 60ft sampling intervals covering 6260ft to 12620ft. The

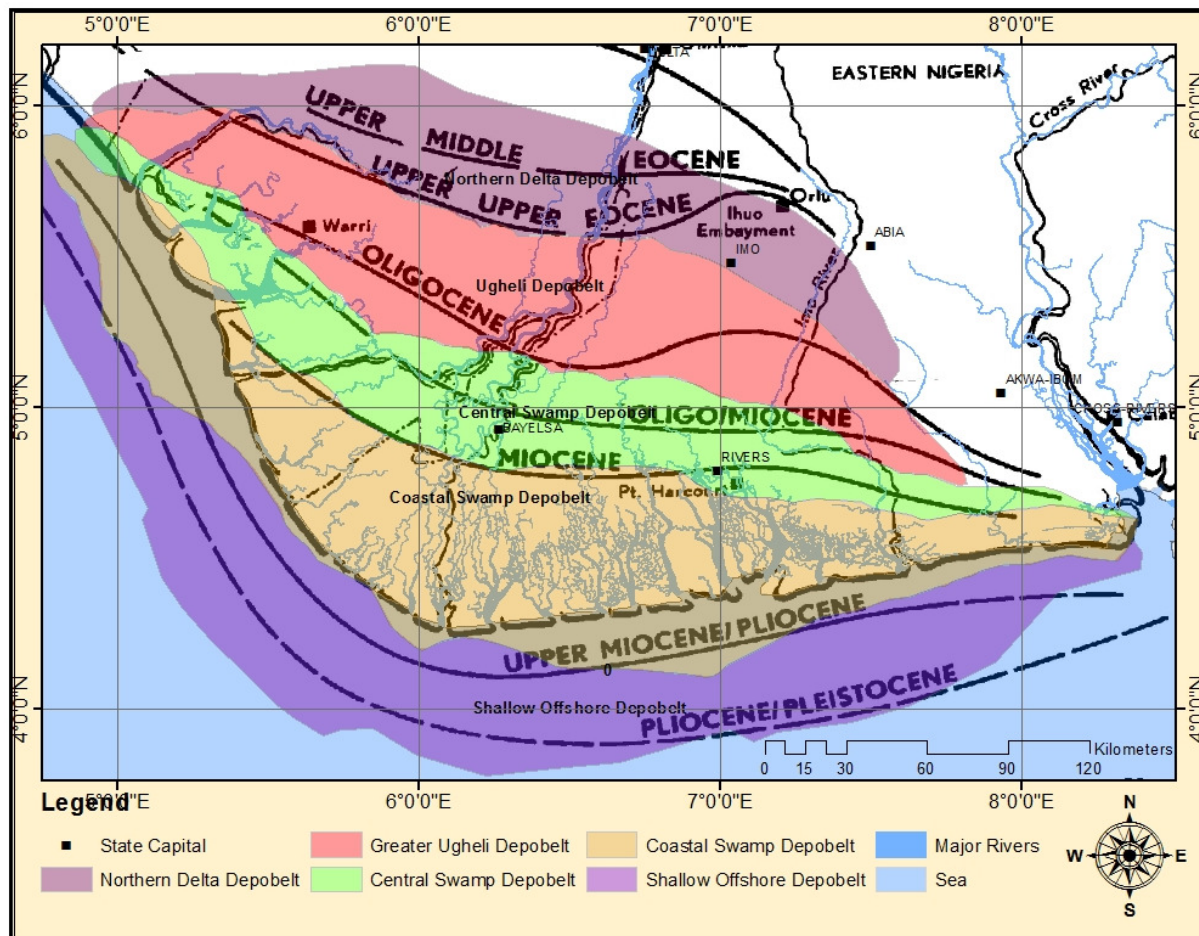


Fig. 2. A map showing the Niger Delta Depobelt (Modified from Doust and Omatsola, 1990).

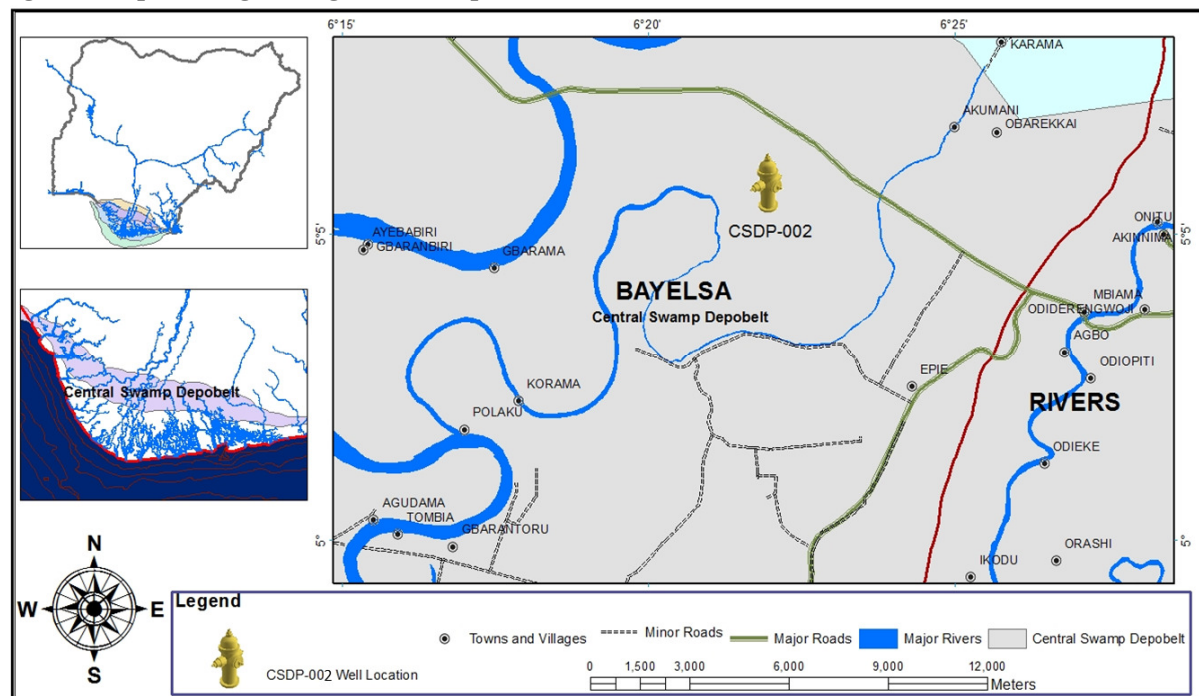


Fig. 3. Map of the study area showing CSDP-002 well.

ditch cuttings were described, prepared for calcareous nannofossils analyses, analyzed and interpreted to generate calcareous nannofossil biostratigraphy of the studied section.

Materials and Methods

The materials on which this study was carried out included 103 ditch cuttings from CSDP-002 well, gamma ray log of the section, Location map of the study well and Niger Delta chronostratigraphic chart. The ditch cuttings ranged in depth between 6260ft to 12620ft and was sampled at 60ft intervals. To attend the research objectives, the following methods was adopted, samples from the studied well was utilized to distinguish the lithological aspects, facies types and fossil content for the Early-Middle Miocene through sample description, standard laboratory sample preparation and biozonation based on Martini (1971) biozonation scheme.

Lithostratigraphy of CSDP-002 Well

The lithology of the studied section of CSDP-002 well is characterized by the alternation of sandstone and sand bodies with shale layers (Fig. 4). It comprised of an upper section in which sandstone/shale alternations are abundant and the shale intercalations relatively thin and a lower section in which the shale units are more prominent, thicker than the intercalated sandstone units. The sand bodies and sandstone units are very fine to coarse grained, predominantly friable and unconsolidated to slightly indurated with silty and calcareous matrices. Sorting is predominantly poor with few moderately medium to coarse grained sandstone units. The sandstones consist of shell fragments and glauconite. The shales are dark grey, fissile to moderately indurated, microfauna rich, calcareous and dense. They become sandy and silty towards the top of the section (table 1).

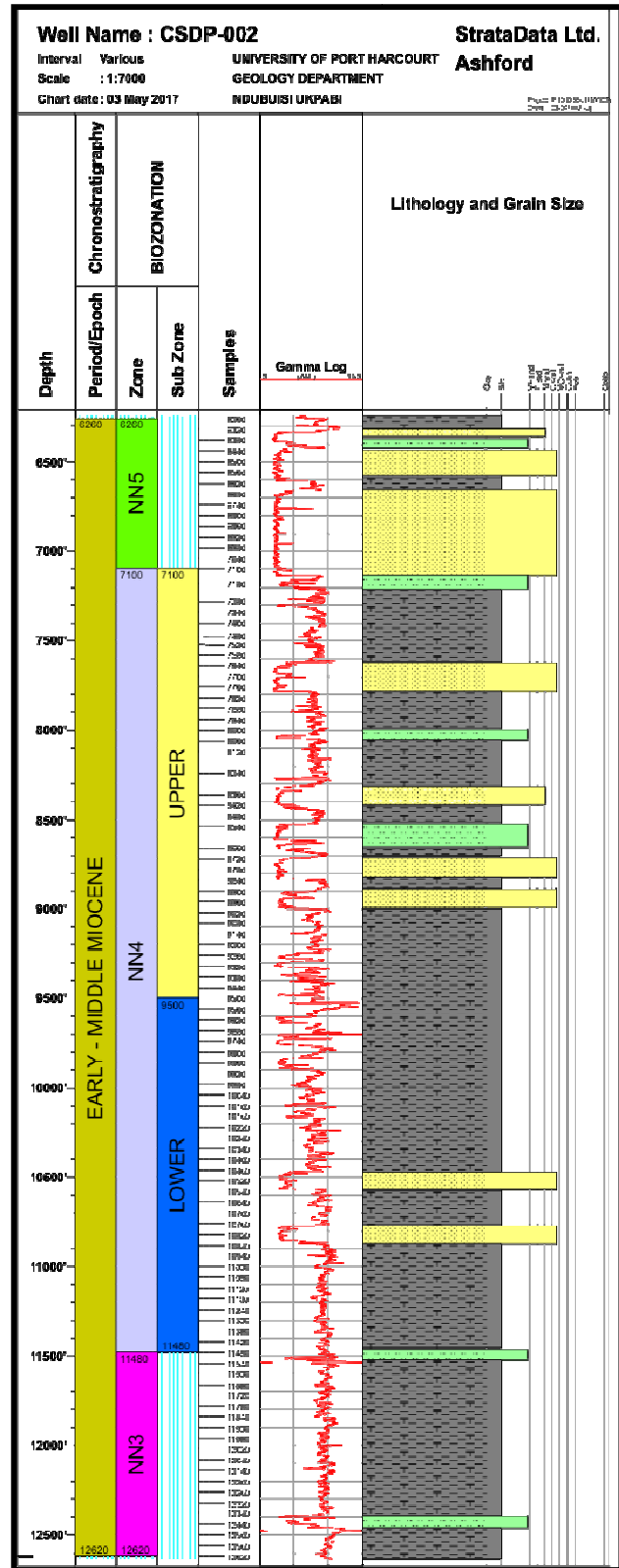


Fig. 4. Gamma ray log signatures and lithologic log of CSDP-002 showing sand and shale intercalations of Agbada Formation.

Table 1. Lithostratigraphic description of CSDP-002 well.

DEPTH (FT)	LITHOLOGY	LITHOSTRATIGRAPHY
6260 - 7180	Sand with shale streaks	AGBADA FORMATION
7180 - 9020	Shale with sand streaks	
9020 - 10460	Shale	
10460 - 12620	Shale with sand streaks	

Interval: 6260ft – 7180ft**Lithological unit: Sand with shale streaks**

This interval is characterized by sand with shale streaks. It consists of the upper section of the Agbada Formation in which sandstone/shale alternations are more abundant and the shale intercalations are relatively thin. The sand is the predominant lithology in this interval. The sandstones are very fine to coarse grained, slightly consolidated with silt and calcareous matrices. The sandstones are poorly to moderately sorted. The shale in this interval are light grey in colour, fissile, calcareous to non-calcareous and contains less of microfauna and glauconite.

Interval: 7180ft – 9020ft**Lithological unit: Shale with sand streaks**

This interval consists of shale with sand streaks. It is a part of the lower unit of the Agbada Formation characterized with shale units that become more prominent and thicker than the intercalated sandstone and sand bodies. The shale is dense, grey to black in colour, microfauna rich, calcareous and mostly moderately indurated. The sand layers are thin, friable to slightly consolidated but predominantly unconsolidated, fine to medium grained and moderately sorted.

Interval: 9020ft – 10460ft**Lithological unit: Shale**

This lithologic interval consists of predominantly shale. It constitutes the thickest shale unit within the studied interval. It is part of the lower unit of the Agbada Formation. The shale unit is dense, grey to black in colour, moderately indurated to sub-fissile, and contains abundant microfauna and other carbonaceous material, rich in shell fragments and glauconite.

Interval: 10460ft – 12620ft**Lithological unit: Shale with sand streaks**

This interval consists of shale with sand streaks. It is a part of the lower unit of the Agbada Formation characterized with shale units that become more prominent and thicker than the intercalated sandstone and sand bodies. The shale is dense, grey to black in colour, microfauna rich, calcareous and mostly moderately indurated. The sand layers are thin, predominantly unconsolidated, fine to medium grained and moderately sorted.

Results and Discussion

CSDP-002 well is rich in fossil assemblages recovered in terms of abundance and diversity. The studied section was characterized into biozones using important recovered marker species such as *Sphenolithus belemnus*, *Helicosphaera ampliaperta* and *Sphenolithus heteromorphus*. The results of the data generated from CSDP-002 well and presented in strataBugs charts is as shown in (fig. 5) and plate 1. The chart showed occurrences of other taxa such as *Calcidiscus leptoporus*, *Coccolithus pelagicus*, *Cyclicargolithus floridanus*, *Cyclococcolithus abisectus*, *Discoaster musicus*, *Discoaster variabilis*, *Helicosphaera carteri*, *Pontosphaera multipora*, *Reticulofenestra haqii*, *Braarudosphaera bigelowii*, *Calcidiscus tropicus*, *Coccolithus miopelagicus*, *Helicosphaera euphratis*, *Helicosphaera intermedia*, *Calcidiscus premacintyreii*, *Discoaster intercalaris*, *Helicosphaera granulata*, *Reticulofenestra minuta*,

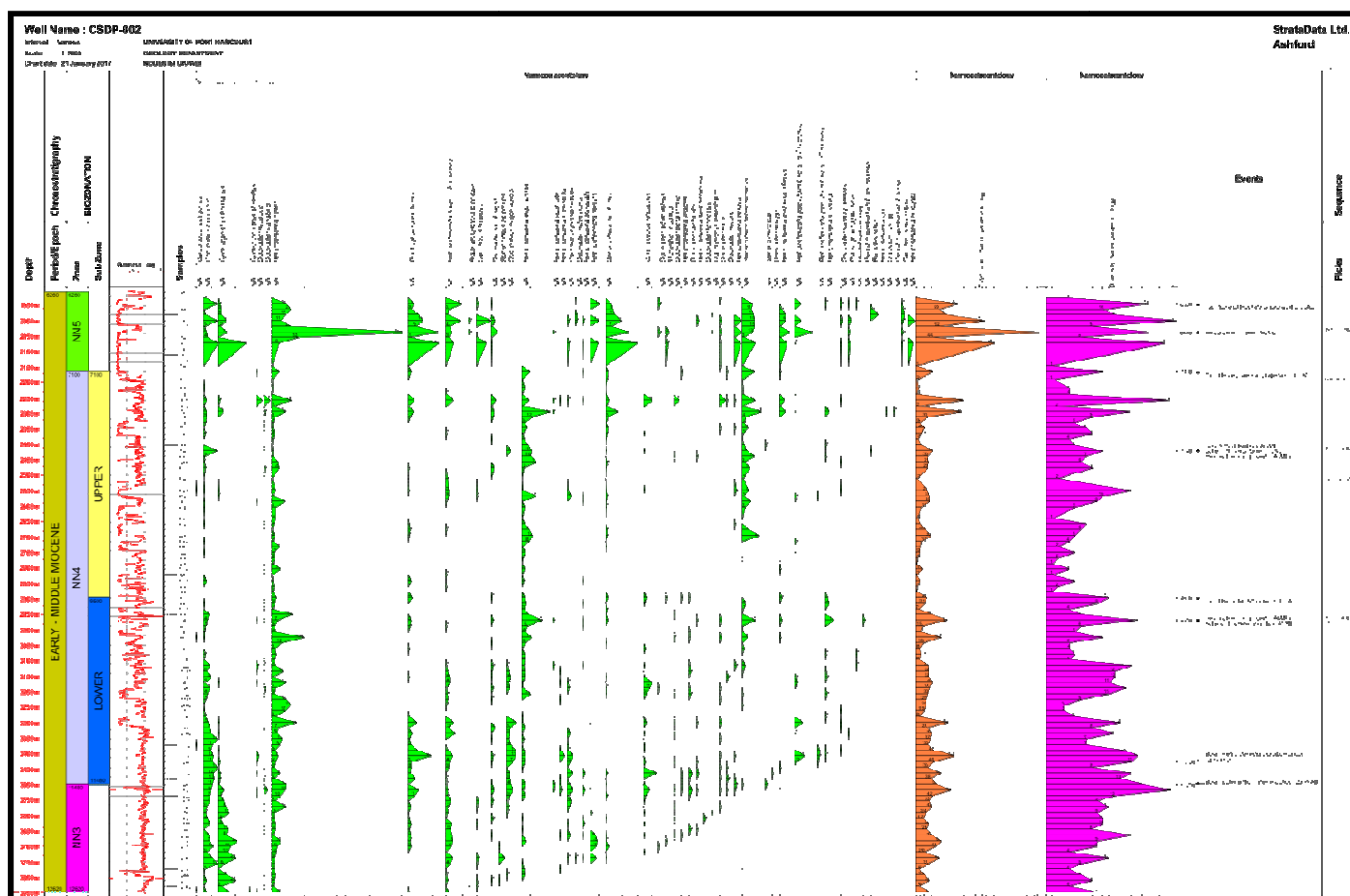


Fig. 5. Biostratigraphic chart of CSDP-002 well.

Reticulofenestra pseudoumbilicus, *Sphenolithus moriformis*, *Coronocyclus nitescens*, *Discoaster adamanteus*, *Micrantholithus flos*, *Discoaster petaliformis*, *Helicosphaera vedderi*, *Discoaster deflandrei*, *Helicosphaera mediterranea*, *Discoaster formosus*, *Clausicoccus fenestratus*, *Discoaster exilis*, *Discoaster moorei*, *Helicosphaera obliqua*, *Discoaster drugii*, *Helicosphaera walbersdorfensis*, *Helicosphaera scissura*, *Discoaster sanmiguelensis*, *Pontosphaera japonica*, *Pseudotriquetrorhabdulus inversus*, *Blackites stilus*, *Clausicoccus spp.*, *Calcidiscus macintyreii* and *Helicosphaera elongata*.

The stratigraphic distributions of markers within the studied section of CSDP-002 well suggested biozonation interpretations as follows:

NN3 zone: (11480ft – TD)

TOP: (LDO/FAD: *Sphenolithus heteromorphus*)

BASE: (Not penetrated)

This interval is the deepest interval penetrated by the studied section in the well. The zone is characterized on top by Base (Last Downhole Occurrence/First Appearance Datum (LDO/FAD) of *Sphenolithus heteromorphus* at 11480ft. The base of this zone is defined by Base (Last Downhole Occurrence/First Appearance Datum (LDO/FAD) of *Sphenolithus belemos*, which was not met by the studied section. Another distinctive common marker found within this interval is *Calcidiscus premacintyreii*.

NN4 zone: (7100ft – 11480ft)

TOP: (FDO/LAD: *Helicosphaera ampliaperta*)

BASE: (LDO/FAD: *Sphenolithus heteromorphus*)

This interval is constrained by distinctive and abundant occurrences of *Helicosphaera ampliaperta* and *Sphenolithus heteromorphus*. The interval is marked at the top with the Top (First Downhole Occurrence/Last Appearance Datum (FDO/LAD) of *Helicosphaera ampliaperta* at 7100ft. It comprised of fairly high diversity of taxa. The Early Miocene taxa such as *Helicosphaera obliqua* and *Coccolithus nitescens* persisted in this zone and are joined by a range of new assemblages such as *Calcidiscus premacintyreii* and *Discoaster exilis*. Common species occurring within the zone are *Cycliargolithus floridanus*, *Coccolithus pelagicus*, *Calcidiscus spp.*, *Sphenolithus moriformis*, *Sphenolithus heteromorphus*, *discoaster exilis* and *Helicosphaera carteri*. The base of this zone is marked with the Base (Last Downhole Occurrence/First Appearance Datum (LDO/FAD) of *Sphenolithus heteromorphus* at 11480ft.

NN5 zone: (6380ft – 7100ft)

TOP: (FDO/LAD: *Sphenolithus heteromorphus*)

BASE: (FDO/LAD: *Helicosphaera ampliaperta*)

Sphenolithus heteromorphus characterized this zone. Like NN4 zone, there are distinctive and abundant occurrences of *Sphenolithus heteromorphus* within this interval. The zone is marked at the top with Top (First Downhole Occurrence/Last Appearance Datum/ (FDO/LAD) of *Sphenolithus heteromorphus* at 6380ft. The base of the zone is marked with the Top (First Downhole Occurrence/Last Appearance Datum (FDO/LAD) of *Helicosphaera ampliaperta* marked at 7100ft. It comprises of fairly high diversity of taxa as was seen in NN4 zone. The Early Miocene taxa such as *Helicosphaera obliqua* and *Coccolithus nitescens* persisted and are more abundant than in NN4 zone and are joined by a range of new assemblages such as *Calcidiscus premacintyreii* and *Discoaster exilis* like in NN4 zone. Common species occurring within NN5 zone are *Cycliargolithus floridanus*, *Coccolithus*

pelagicus, *Calcidiscus spp.*, *Sphenolithus moriformis*, *discoaster exilis*, *Helicosphaera carteri*, *Umbilicosphaera jafari* and *Umbilicosphaera rotula*.

Discussion

The studied section of CSDP-002 well comprised of abundant taxa with high diversity of species which were characterized into biozone on the recognition of diagnostic species such as *Sphenolithus belemnus*, *Helicosphaera ampliaperta* and *Sphenolithus heteromorphus*. *Sphenolithus belemnus* under the microscope is dart-shaped, narrow, small sphenolith with 10 – 12 spines and has a flat base (Bramlette & Wilcoxon, 1967). The sphenolith showed a tapered up uniformed pointed apical spine. The spines are distinctive and are easily identified under crossed nichols. It first occurred in upper chron C6N sub-Magnetochron 19Ma, and last occurred in lower chron C5Dr.2r sub-Magnetochron 18Ma; (Raffi et al, 2006). *Helicosphaera ampliaperta* under the microscope showed ellipsoidal/nearly oval outline, with an outer rim modified into a helical flange that ends in a wing. There is no bridge/bar in the large central opening but the central opening has two nodes, each at the end of the shorter axis of the central opening. It first occurred in NN2 zone (18.28 – 22.82)Ma and last occurred within NN4 zone (14.97 – 17.95)Ma (Young, 1998). *Sphenolithus heteromorphus* under the microscope is conical – shaped with several elements radiating from a common well developed quadrate base. It has a well-developed apical spine with bulb-like base, equal or almost equal lateral and proximal elements which formed the major difference from *Sphenolithus belemnus* (Deflandre, 1952). It ranged in size from 5 – 15µm in length and 3 – 5µm in width. It first occurred in NN4 zone (14.91 – 17.95)Ma and last occurred within NN5 zone (13.53 – 14.91)Ma (Young, 1998). The stratigraphic distributions of these markers within the studied section of CSDP-002 well suggested that the studied section penetrated NN5 to upper NN3 of

DEPTH (Ft)	BIOEVENTS (This work)	AGE (Ma) Haq, et al., 1988	NN ZONE Martini, 1971	SUBZONE	INFERRED RELATIVE AGES
6380	☐ FDO/LAD: <i>Sphenolithus heteromorphus</i>		NN5		MIDDLE MIOCENE
6680	☐ MFS: 15.00Ma [<i>Helicosphaera cartari</i> (ACME)]	15.00			
7100	☐ FDO/LAD: <i>Helicosphaera ampliaperter</i>				
7180	☐ SB 15.5 (Lan 2/Ser 1)	15.50	NN4	UPPER	EARLY MIOCENE
7940	☐ MFS: 15.90Ma [<i>Helicosphaera ampliaperter</i> (ACME) <i>Sphenolithus moriformis</i> (ACME) <i>Coccolithus pelagicus</i> (ACME)]	15.90			
8210	☐ SB 16.5 (Bur 5/Lan 1)	16.50		LOWER	
9500	☐ FDO/LAD: <i>Discoaster deflandrei</i>				
9710	☐ MFS: 17.40Ma [<i>Helicosphaera ampliaperter</i> (ACME) <i>Sphenolithus heteromorphus</i> (ACME)]	17.40	NN3		
11240	☐ LDO/FAD: <i>Reticulofenestra pseudumbilicus</i>				
11480	☐ LDO/FAD: <i>Sphenolithus heteromorphus</i>				
12620	☐ Base Sample Analysed				

Fig. 6. Biostratigraphic frame work of CSDP-002 well.

Martini (1971) biozonation scheme. NN5 is marked at the top with Top (First Downhole Occurrence/Last Appearance Datum/ (FDO/LAD) of *Sphenolithus heteromorphus* at 6380ft. The base of the zone is marked with the Top (First Downhole Occurrence/Last Appearance Datum (FDO/LAD) of *Helicosphaera ampliaperter* marked at 7100ft. NN4 is marked at the top with the Top (First Downhole Occurrence/Last Appearance Datum (FDO/LAD) of *Helicosphaera ampliaperter* at 7100ft. The base of this zone is marked with the Base (Last Downhole Occurrence/First Appearance Datum (LDO/FAD) of *Sphenolithus heteromorphus* at 11480ft. NN3 is characterized on top by Base (Last Downhole Occurrence/First Appearance Datum (LDO/FAD) of

Sphenolithus heteromorphus at 11480ft, occurrence of *Sphenolithus belemos*, LAD of *Discoaster druggii* and continuous occurrence of *Helicosphaera scissura* below FAD of *Sphenolithus heteromorphus* which marked the base of NN4. The base of NN3 is defined by Base (Last Downhole Occurrence/First Appearance Datum (LDO/FAD) of *Sphenolithus belemos*, which was not met in the studied section. The studied section penetrated MFS 17.40Ma at 9740ft marked with well-developed nannofossil abundance and diversity with explosive events (ACME) of *Helicosphaera ampliaperter*, *Helicosphaera scissura* and *Sphenolithus heteromorphus* within NN4 zone, MFS 15.90Ma at 7940ft marked with explosive events (ACME) of

Explanation of Plate 1 Photographs

Plate	Species	Depth and well of occurrence
1	<i>Sphenolithus heteromorphus</i>	10640ft, CSDP-002 well
2	<i>Sphenolithus heteromorphus</i>	11480ft, CSDP-002 well
3	<i>Sphenolithus moriformis</i>	10340ft, CSDP-002 well
4	<i>Helicosphaera vedderi</i>	11360ft, CSDP-002 well
5	<i>Helicosphaera ampliaperta</i>	10760ft, CSDP-002 well
6	<i>Helicosphaera ampliaperta</i>	9800ft, CSDP-002 well
7	<i>Helicosphaera ampliaperta</i>	11300ft, CSDP-002 well
8	<i>Calcidiscus premacintyreii</i>	11240ft, CSDP-002 well
9	<i>Coccolithus miopelagicus</i>	10220ft, CSDP-002 well
10	<i>Cyclicargolithus floridanus</i>	6440ft, CSDP-002 well
11	<i>Cyclicargolithus floridanus</i>	8420ft, CSDP-002 well
12	<i>Reticulofenestra haqii</i> (3-5 microns)	11300ft, CSDP-002 well
13	<i>Helicosphaera obliqua</i>	10220ft, CSDP-002 well
14	<i>Helicosphaera mediterranea</i>	8000ft, CSDP-002 well
15	<i>Discoaster brouweri</i>	8540ft, CSDP-002 well
16	<i>Helicosphaera vedderi</i>	11420ft, CSDP-002 well
17	<i>Blackites inversus</i>	9740ft, CSDP-002 well
18	<i>Coronocyclus nitescens</i>	7400ft, CSDP-002 well

Helicosphaera ampliaperta, *Sphenolithus heteromorphus* and increase in *Helicosphaera cartari* and *Helicosphaera moriformis* in NN4 zone, and MFS 15.00Ma at 6680ft marked with explosive event (ACME) of *Helicosphaera cartari*, Increase in *Sphenolithus moriformis* and influx of *Sphenolithus heteromorphus* in NN5 zone. Two sequence boundary was delineated which are SB 16.5 (Bur 5/Lan 1) at 8240ft marked with an abrupt drop in abundance and diversity of taxa in NN4 zone and SB 15.5 (Lan 2/Ser 1) at 7180ft marked with complete absence of taxa within NN4 zone.

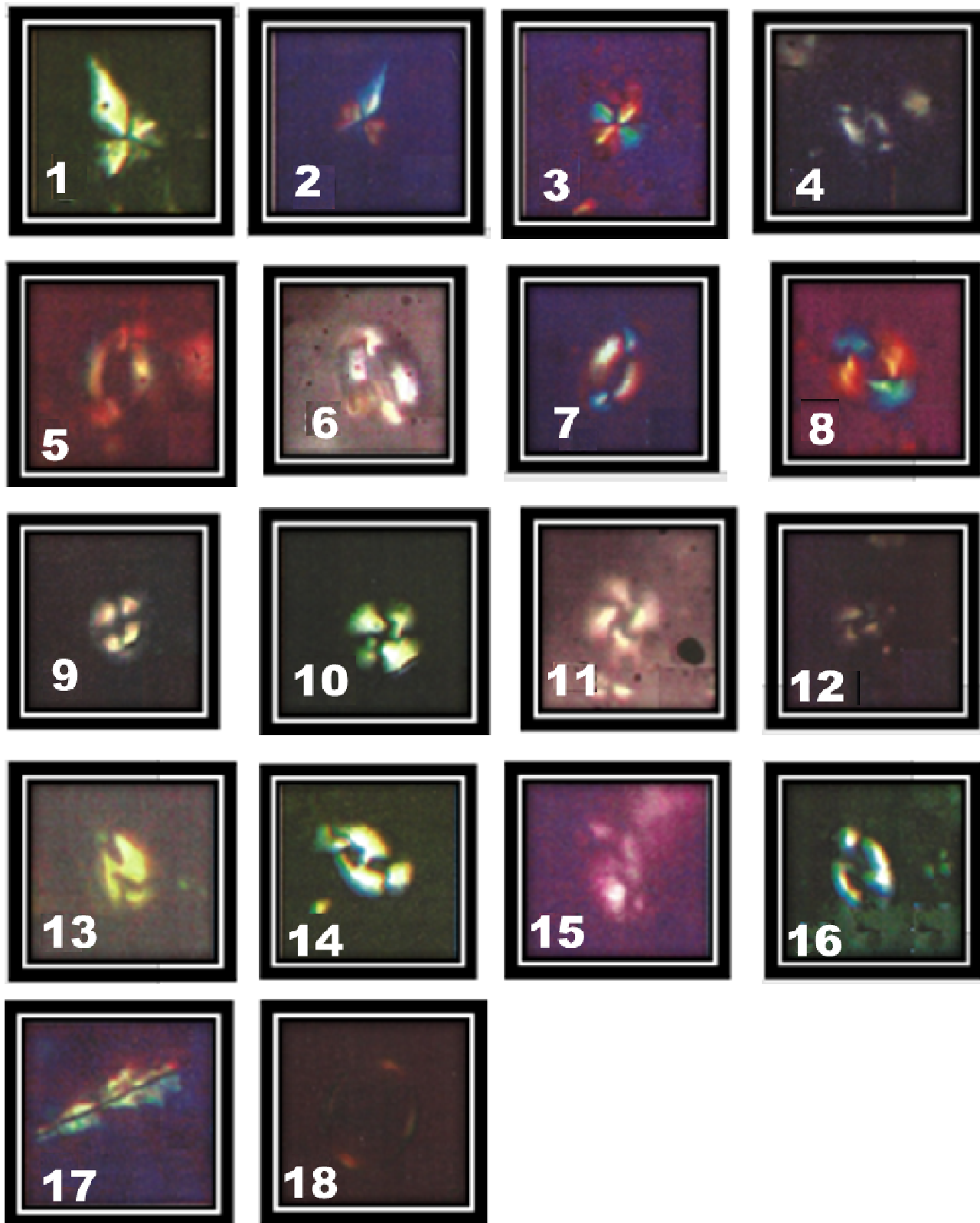
The biostratigraphic frame work of the studied section of CSDP-002 well comprised of Top occurrence of *Sphenolithus heteromorphus*, and *Discoaster petaliformis*, Base occurrence of *Discoaster sanmiguelensis* which corresponded to NN5 zone, distinguishable Top occurrence of *Helicosphaera*

ampliaperta which marked the Top of NN4, Last Downhole Occurrence/First Appearance Datum LDO/FAD of *Reticulofenestra pseudumbilicus* and *Calcidiscus premacintyreii* which are markers indicative of NN4 zone, Top occurrence of *Discoaster druggii*, base occurrence of *Sphenolithus heteromorphus* and *Helicosphaera scissura* which corresponded to NN3 of Martini, (1971) biozonation scheme. The biostratigraphic frame work of CSDP-002 Well is shown in Fig. 6.

Conclusion

The top and base of the studied section of CSDP-002 well is within the Agbada Formation of the Niger Delta, this is indicated by the alternation of sandstone and sand bodies with shale layers. The stratigraphic range of the fossil assemblages indicated that the studied section lies within top NN3 zone indicated

Plate 1. Photographs of nannofossils.



Note*: All photomicrographs in Plate 1 were taken at 1000X magnification.

with (LDO/FAD) of *Sphenolithus heteromorphus*; top and base of NN4 zone indicated with (FDO/LAD) of *Helicosphaera ampliaperta* and (LDO/FAD) of *Sphenolithus heteromorphus* respectively and base of NN5 zone indicated with (FDO/LAD) of *Sphenolithus heteromorphus*. The studied section of CSDP-002 corresponded to 15.0Ma to 17.40Ma in age and penetrated MFS 15.00Ma; MFS 15.90Ma and MFS 17.40Ma maximum flooding surfaces and SB 15.5 (Lang 2/Ser. 1) and SB 16.5 (Bur. 5/Lan. 1) sequence boundary's.

References

- Bramlette M. N., Wilcoxon J. A. (1967). Middle Tertiary calcareous nannoplankton of the Cipero section, *Trinidad, W. I. Tulane Studies in Geology*, 5(3), 93-131.
- Deflandre, G. (1952). Sur les nannofossiles calcaires et leur systematique. *Rev. Micropaléontologie*,. 2, 127.
- Doust, H and Omatsola, E. (1990). Niger Delta. In: J. D. Edwards and P.A. Santogrossi, eds., Divergent/passive margin basins, *AAPG Memoir*, 48, 239-248.
- Haq, B. U., Hardenbol, J and Vail, P. R. (1988). Mesozoic and Cenozoic chronostratigraphy and cycles of sea-level change. *Society of Economic Paleontologists and Mineralogists, Special Publication*, 42, 71–108.
- Martini, E. (1971). Standard Tertiary and Quaternary calcareous nannoplankton zonation. In: A. Farinacci (ed.), *Proceeding of 2nd Planktonic Conference, Roma 1970, Roma. Tecnoscienza*, Rome, 739–785.
- Raffi, I., Jan, B., Eliana, F., Heiko, P., Domenico, R., Lucas L., Frits, H. (2006). A review of calcareous nannofossil astrobiochronology encompassing the past 25 million years. *Quaternary Science Reviews*, 25, 3113–3137.
- Tuttle, L. W. M., Charpentier, R. R and Brownfield, E. M. (1999). The Niger Delta Petroleum System. Niger Delta Province, Nigeria, Cameroon, and Equatorial Guinea, Africa. *U.S Geological Survey Open – file Report 99 – 50 – H*, Denver, Colorado, 70 pp.
- Young, J. R. (1998). Neogene. In Bown, P. R., (Ed.), *Calcareous Nannofossil Biostratigraphy: Kluwer Academic Publ.* Dordrecht, The Netherlands, pp. 225–265.

Cite this article: Ukpabi, N., Udom, J.G., and Okengwu, O.K. 2018. Calcareous Nannofossil Biostratigraphy of CSDP-002 Well, Central Swamp Depobelt, Niger Delta, Nigeria. *International Basic and Applied Research Journal*, Volume 04, Number 02, pp. 1-11.